STAFF SUMMARY SHEET

	TO	ACTION	SIGNATURE *(Surname)*, GRADE AND DATE		TO	ACTION	SIGNATURE *(Surname)*, GRADE AND DATE
1	USAFA/ DFAN	sig	*Reison Ceremony* HEAD 7 Feb 2014	6			
2	USAFA/ DFER	approve	KRAUS, Col 10Feb14	7			
3	USAFA/ DFAN	action	(Author / Originator)	8			
4				9			
5				10			

SURNAME OF ACTION OFFICER AND GRADE	SYMBOL	PHONE	TYPIST'S INITIALS	SUSPENSE DATE
Coley, O-3	USAFA/DFAN	333-9223	cjc	20140206

SUBJECT		DATE
Clearance for Material for Public Release USAFA-DF-PA- 38		20140213

SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.

Authors: Andrew J. Lofthouse, Christopher J. Coley

Title: FieldView Educational Use at USAFA 2013

Circle one: Abstract   Tech Report   Journal Article   Speech   (Paper)   Presentation   Poster

Thesis/Dissertation   Book   Other: _____

Check all that apply (For Communications Purposes):

       [] CRADA (Cooperative Research and Development Agreement) exists

       [] Photo/ Video Opportunities   [] STEM-outreach Related   [] New Invention/ Discovery/ Patent

Description: Statement of FieldView Educational Use at USAFA during calendar year 2013

Release Information: Intelligent Light, 301 Route 17 North, 7th Floor, Rutherford, NJ 07070

Previous Clearance information: None

Recommended Distribution Statement: Distribution A, Approved for Public release, distribution unlimited.

3. DISCUSSION. N/A

4. RECOMMENDATION. Sign coord block above indicating document is suitable for public release. Suitability is based soley on the document being unclassified, not jeopardizig DoD interests, and accurately portraying official party.

ANDREW J. LOFTHOUSE, Lt Col, USAF
Director, Modeling & Simulation Research Center

2 Tabs
1. FieldView Educational Use at USAFA 2013
2. Attachment to FieldView Educational Use at USAFA 2013

AF IMT 1768, 19840901, V5   PREVIOUS EDITION WILL BE USED.

FieldView Education License Usage Annual Report
U.S. Air Force Academy
6 February 2014
Lt Col Andrew Lofthouse

1) List of publications where FieldView images were used:

Ghoreyshi, M. and Cummings, R. M., "Challenges in the Aerodynamics Modeling of an Oscillating and Translating Airfoil at Large Incidence Angles," Aerospace Science and Technology, Volume 28, Issue 1, July 2013, Pages 176-190

Ghoreyshi, M., Jirasek, A., Cummings, R. M., Tomaro, R. and Wurtzler, K. "Static and Dynamic Loads Modeling of an Aerodynamic Control Surface," 51st AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition, AIAA Paper 2013-664, January 2013.

Ghoreyshi, M., Jirasek, A. and Cummings, R. M.," Unsteady Aerodynamic Modeling of Aircraft Control Surfaces by Indicial Response Methods," 31st AIAA Applied Aerodynamics Conference, AIAA Paper 2013-2535, June 2013

Ghoreyshi, M., Cummings, R. M., Da Ronch, A. and Badcock, K. J., "Transonic Aerodynamic Load Modeling of X-31 Aircraft Pitching Motions," AIAA Journal, Volume 51, 2013, Pages 2447-2464

Fagley, C., Farnsworth, J., Porter, C., Seidel, J., McLaughlin, T., Lee, J., and Lee, E., "Open-Loop Dynamics of the Asymmetric Vortex Wake behind an Ogive at High Incidence," Journal of Flow Control, Vol. 5, March 2013, pp. 59–77.

Fagley, C., Porter, C., Seidel, J., Farnsworth, J., and McLaughlin, T., "Experimental Closed-Loop Flow Control of a von Karman Ogive at a High Angle of Attack," AIAA Paper 2013-2924, 2013.

Porter, C., Fagley, C., Farnsworth, J., Seidel, J., and McLaughlin, T., "Closed-Loop Flow Control of a Tangent Ogive at a High Angle of Attack," AIAA Paper 2013-0395, 2013.

Porter, C., Fagley, C., Seidel, J., and McLaughlin, T., "Numerical Simulations of Closed-Loop Flow Control on a Tangent Ogive at a High Angle of Attack," AIAA Paper 2013-2923, 2013.

2) Image files (at high resolution if possible): see attachment hosted on ftp site.

3) Description of how the FieldView licenses were used in your teaching or research:

FieldView was used in two courses during the past year: AE342 (Computational Aerodynamics) and AE472 (Advanced Computational Aerodynamics). AE342 is an introductory course in CFD where cadets learn basic use of grid generation, flow solver, and flow visualization software to

perform two projects: a viscous 2D airfoil project and an inviscid 3D wing project. A FieldView tutorial is completed by all cadets (approximately 70 cadets take the course per year). Cadets in AE472 perform research with faculty on DoD HPC computers and present their results at the end of the semester. There were a total of 5 cadets in AE472 this past year who conducted research on an Air Force 5th-generation aerial target, land speed record car, propulsive wing, aerodynamic simulations of the X-31, and characterization of USAFA's turbine cascade wind tunnel. Some select cadets also participate in our Cadet Summer Research Program (CSRP) or Independent Study (AE499), where they continue their research from AE472 or conduct similar research projects.

In addition, numerous researchers in the Aeronautics Research Center and the Modeling & Simulation Research Center use FieldView on a regular basis. Their research is overviewed in the papers listed above, and includes stability and control modeling, tangent ogive noses at high angles of attack, aerodynamic simulations of a generic UCAV and the X-31, NASA Maraia Capsule longitudinal static stability investigation, weapons bay simulations, and educational research. Detailed descriptions are included below for most of these projects.

Stability and Control Modeling: Our research is focused on identifying and developing high-fidelity reduced order models that capture the nonlinear and unsteady aerodynamic characteristics of air vehicles with moving control surfaces using overset grids. Test cases considered include a fighter, a jet trainer, a generic UCAV, and a parachute canopy providing a mix of aerodynamic, flow control, fluid-structure interaction, and flight dynamic challenges. The aerodynamic responses of these vehicles to different motions and control surface movements are visualized in FieldView. This gives us a unique advantage of investigating the flowfield around the air vehicles at each instant of time spent in maneuvers. These flowfield measurements in wind tunnel or flight tests can be a complicated task that involves many compromises. These tests can only measure a limited time history of flowfield around a maneuvering aircraft. In addition, flight tests are potentially dangerous to perform a full investigation of the aircraft operational flight envelope especially maneuvering at high angles of attack. Another advantage of using FieldView in our research is the methods available in FieldView that can detect and highlight flow features such as shock, flow separation, and vortices.

Tangent Ogive Nose: The flow field around a slender axisymmetric forebody varies dramatically with the angle of attack. Typically, four flow regimes are observed: attached flow, symmetric vortex flow, asymmetric vortex flow, and unsteady wake-like flow. The transition between the symmetric and asymmetric vortex flow is due to an instability of the natural flow field. Minor geometric imperfections and flow perturbations are amplified by this convective instability and divert the flow field away from the symmetric vortex state into an asymmetric vortex state. This phenomenon will cause either the port or starboard vortex to separate from the forebody surface, producing a large asymmetric pressure distribution on the surface or side force. The natural tendency of the flow field to favor an asymmetric vortex state emphasizes the importance of forebody vortex management. Closed-loop active flow control techniques hold the promise to increase stability and improve maneuverability characteristics of slender bodies at high angles of attack at varying flow conditions. In fact, a unique approach, developed at the USAF Academy, to formulating closed-loop control algorithms is employed to control the asymmetric vortex phenomenon through the convective instability.

NASA Maraia Capsule: NASA's Maraia Capsule is a small, autonomous capsule designed to return from low earth orbit from the International Space Station (ISS). It will act as a flight test bed for various capsule systems and provide on-demand sample return for the ISS. NASA Johnson Space Center tasked the United States Air Force Academy Department of Aeronautics to define the baseline aerodynamic characteristics of the capsule in subsonic flight. This baseline characterization included lift, drag and moment data for the capsule at Mach 0.3 and Mach 0.45 between 0 and 28 degrees angle of attack, as well as a shifting center of gravity study.

Weapons Bay Simulations: Unsteady cavity flow produces unsteady aerodynamic forces on a store being released from the cavity. It has been shown that these unsteady forces can lead to non-repeatability of store separation trajectory predictions, which complicates the store certification process. Previous work with OVERFLOW demonstrated that the unsteady loading on a store in a cavity correlates to the Rossiter modes of the empty cavity. The current project is focused on validating the Kestrel flow solver for the investigation of cavity store separation problems and comparison of Kestrel results with the previous OVERFLOW results. Once this is complete, Kestrel will be used to investigate the effects of unsteady cavity flow on store stability and trajectory repeatability, to include the effects of differing geometry and flow conditions.

4) Computer systems used:

USAFA SGI cluster with 12 nodes, each node consisting of two six-core Intel Xeon X5650 (2.67GHz) processors and 4 GB of memory per core, resulting in 144 total cores (used for AE342, AE372, and some research)

Various DoD HPC computers including Spirit, Garnet, Mana, etc.

5) CFD Solvers:

Primarily Cobalt and Kestrel

AE 342 – Computational Aerodynamics

Examples of student work from the junior-level Computational Aerodynamics course. Students begin by taking a given flow solution and analyzing it to get familiar with FieldView capabilities.
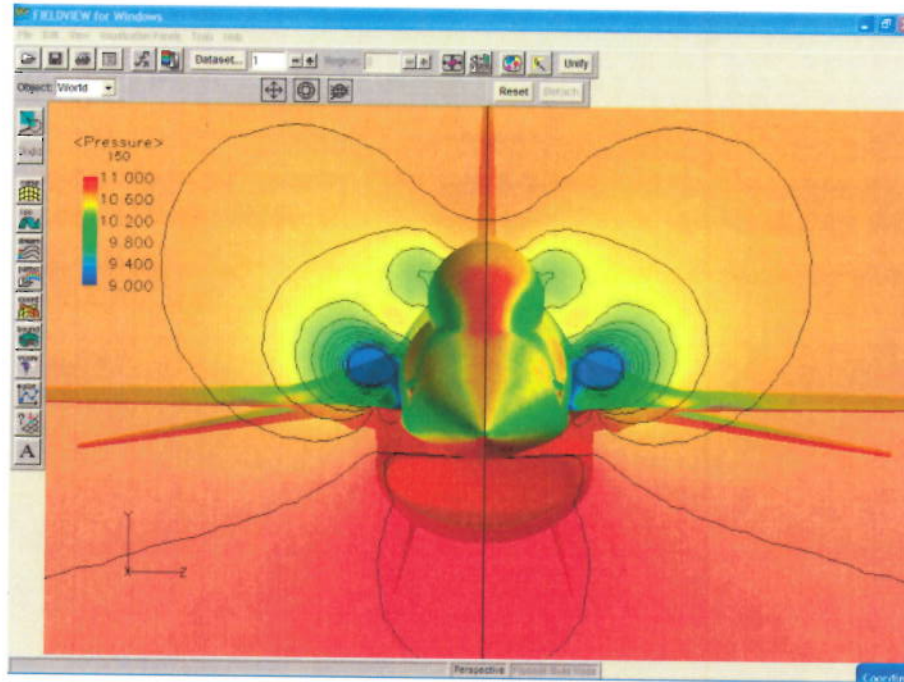
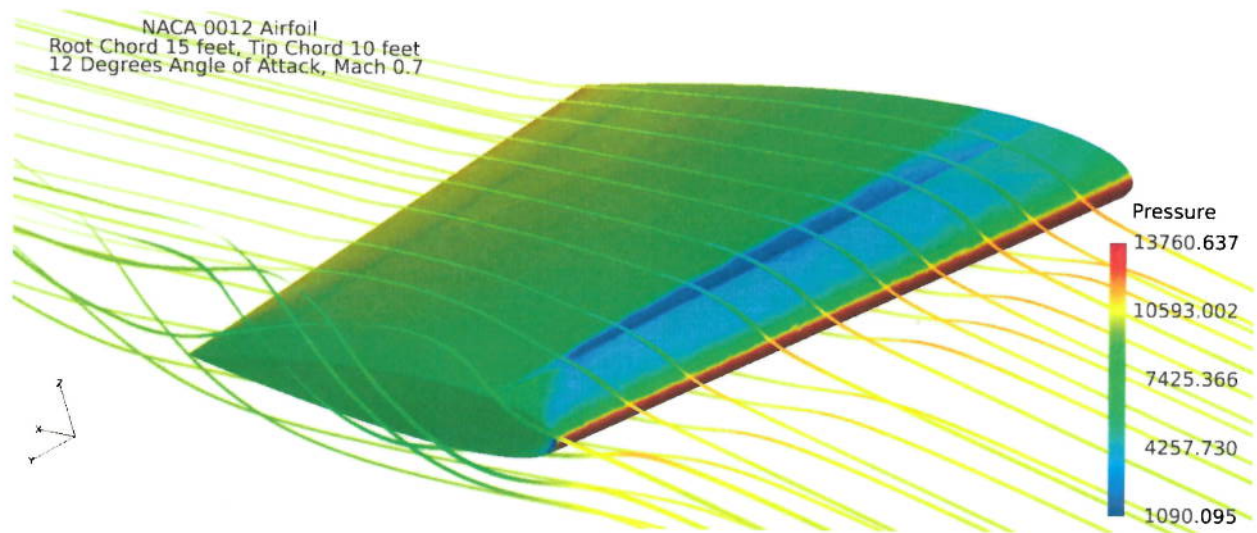Pressure contours on an F-16
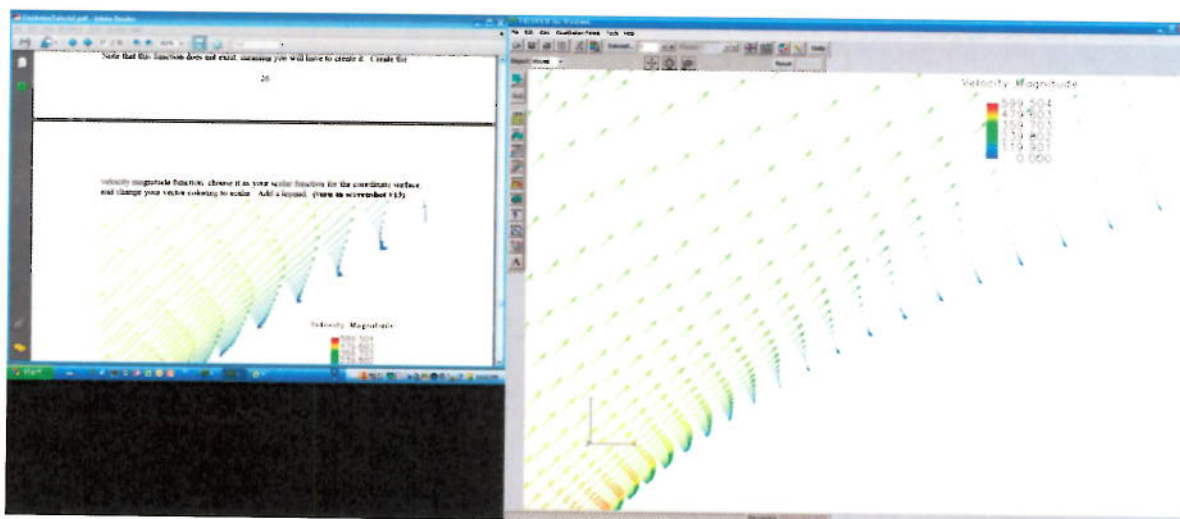
Boundary layer using velocity vectors
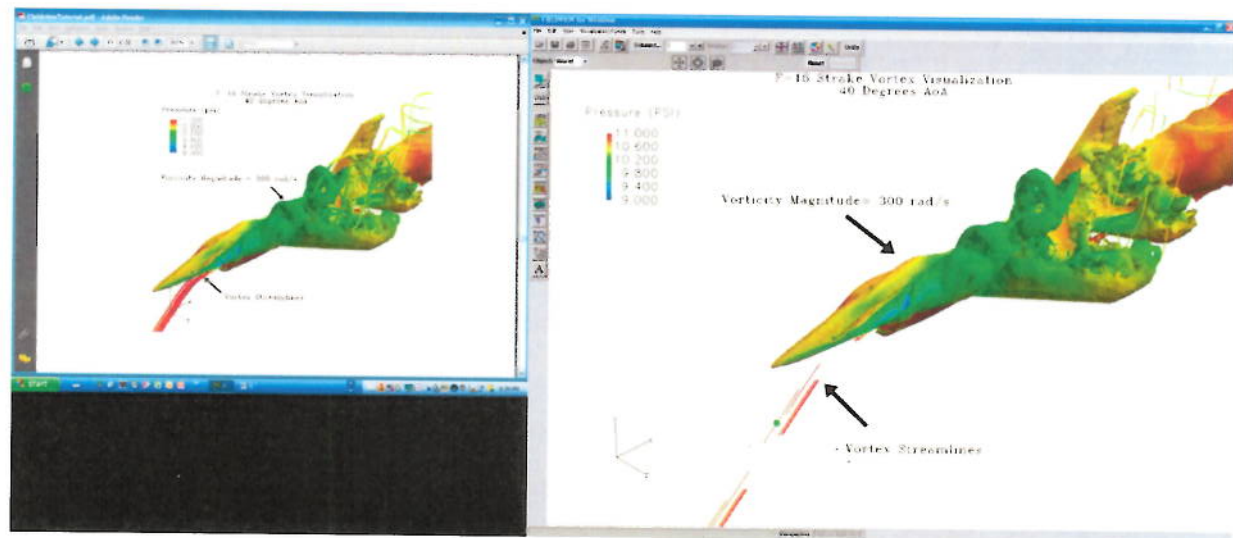
Vortex visualization

Students then compute solutions for an inviscid 3D wing.

NACA 0012 Airfoil
Reference Root Chord and Tip Chord 10 feet
12 Degrees Angle of Attack, 0.7 Mach

Pressure
2411.783
1904.875
1397.966
891.058
384.150
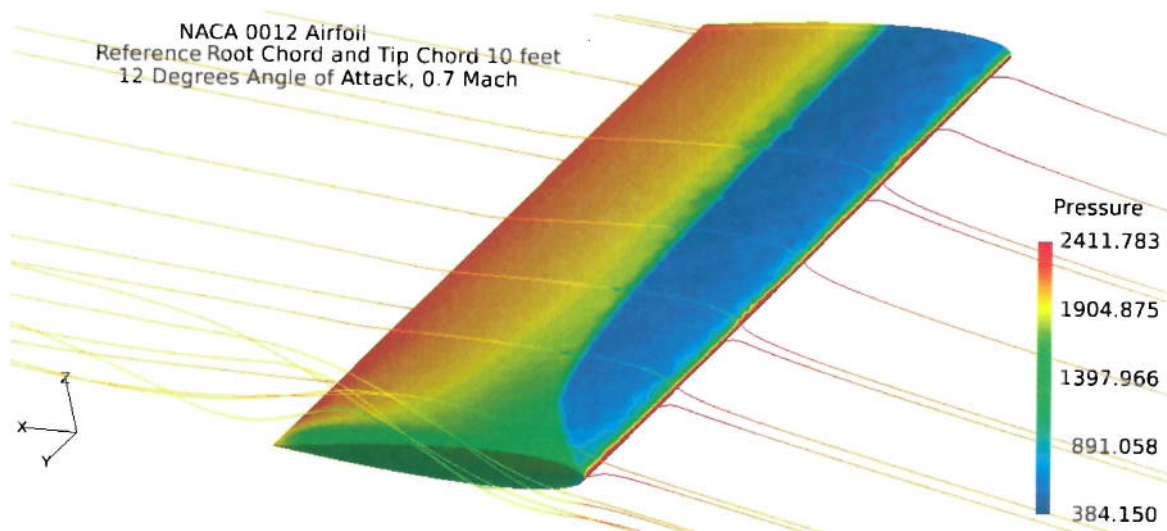
Pressure distribution over wing with taper ratio of 1 at 12° angle of attack and Mach 0.7

NACA 0012 Airfoil
Root Chord 15 feet, Tip Chord 10 feet
12 Degrees Angle of Attack, Mach 0.7

Pressure
13760.637
10593.002
7425.366
4257.730
1090.095

Pressure distribution over wing with a taper ratio of .666 at $12°$ angle of attack and Mach 0.7

Students finish the class with an analysis of a viscous airfoil.

Coefficient of Pressure
6 deg AoA

0.216
-0.143
-0.503
-0.862
-1.222
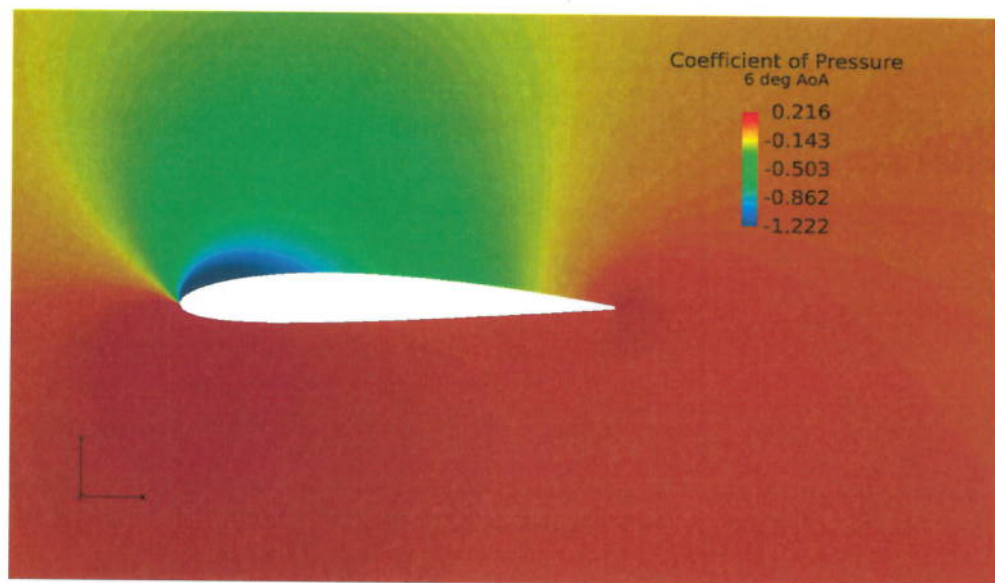
Coefficient of Pressure – NACA 2412 airfoil at $6°$ AoA
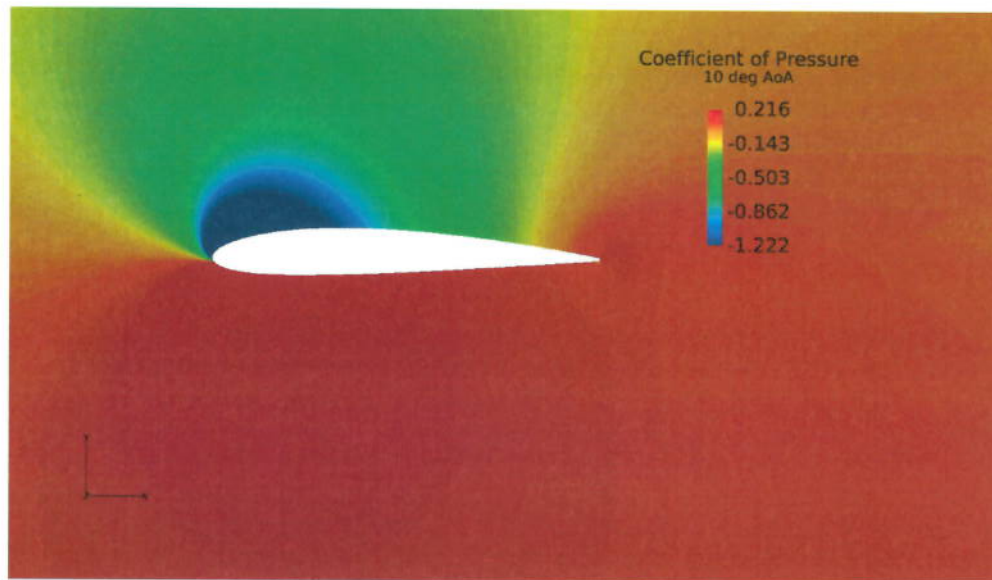
Coefficient of Pressure – NACA 2412 airfoil at 10° AoA
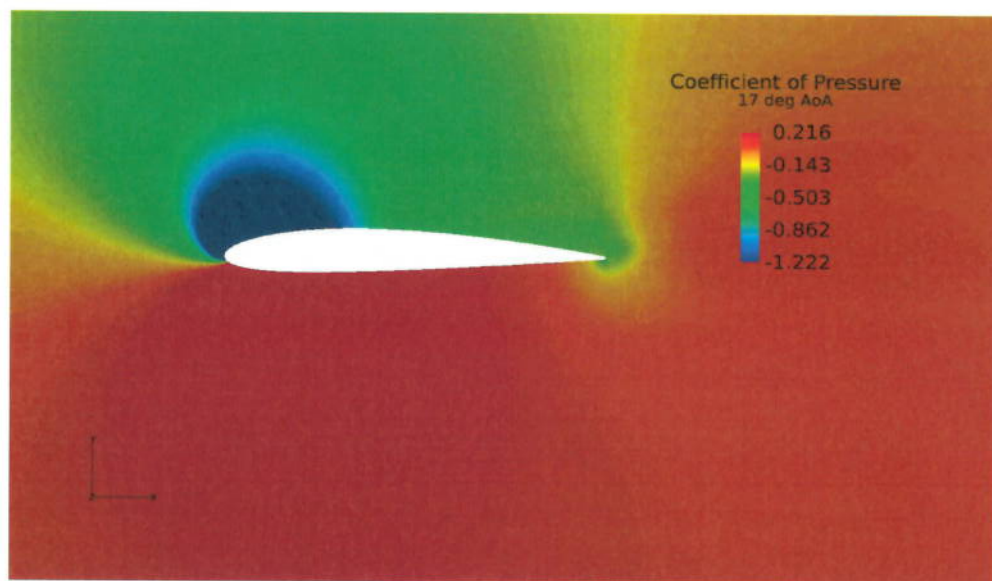
Coefficient of Pressure – NACA 2412 airfoil at 17° AoA

Cadet Research (AE 472 – Advanced Computational Aerodynamics, AE 499 Independent Study, and Cadet Summer Research Program)

Air Force 5th Generation Aerial Target (5GAT)
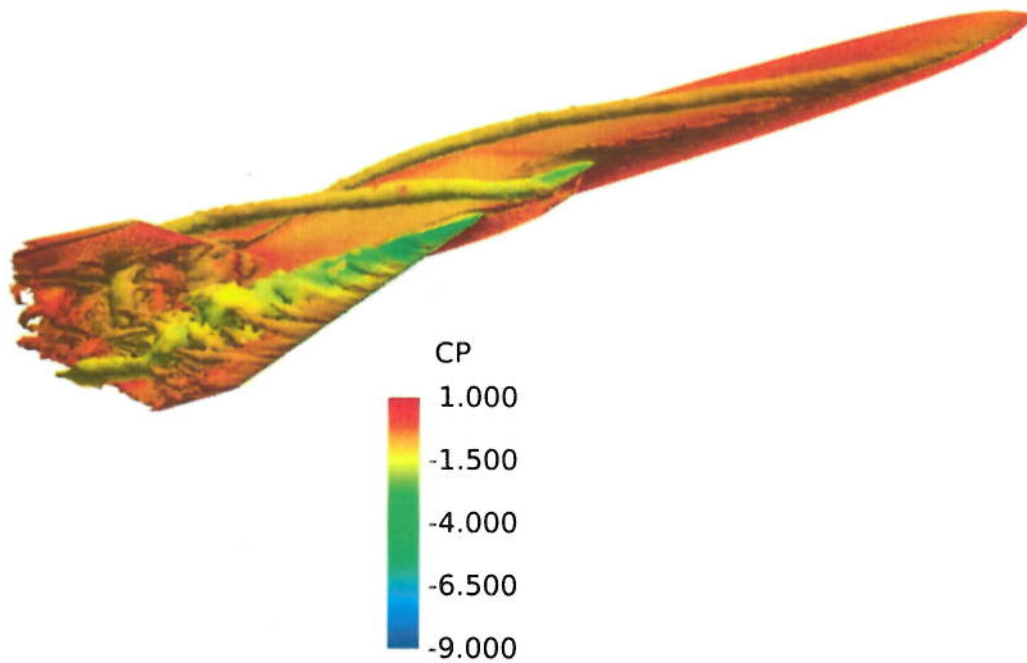
Vortex breakdown over 5GAT wing at 20 degrees AoA and Mach 0.3
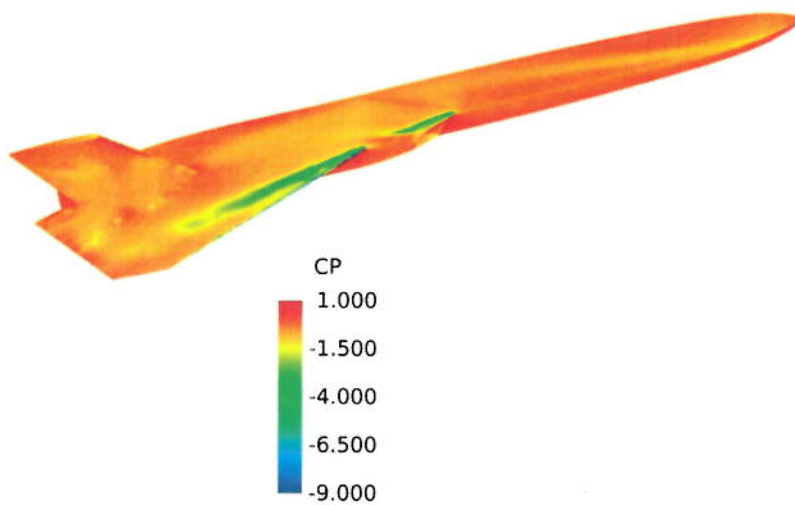
Pressure coefficient distribution over 5GAT Surface

Land Speed Record Car
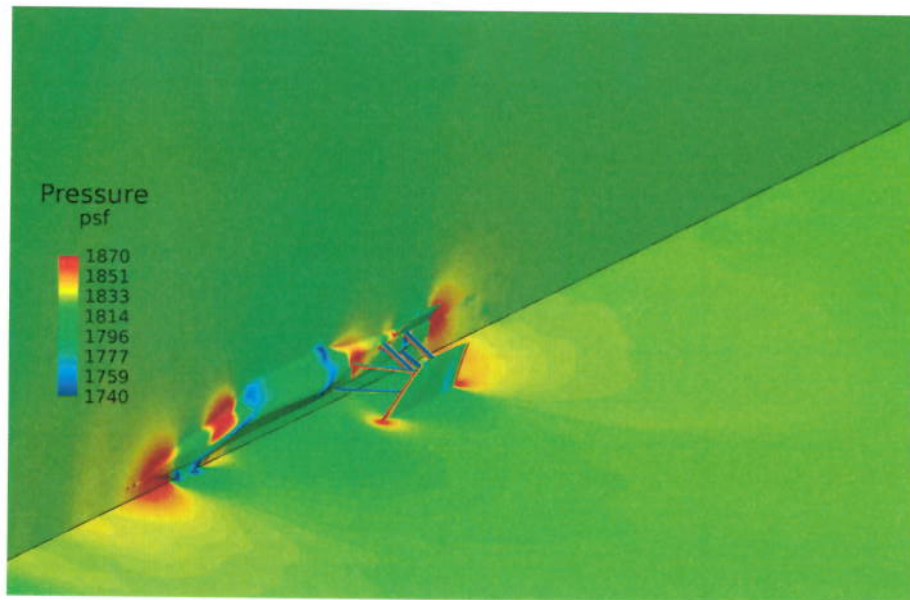
Pressure Distribution Mach 0.5
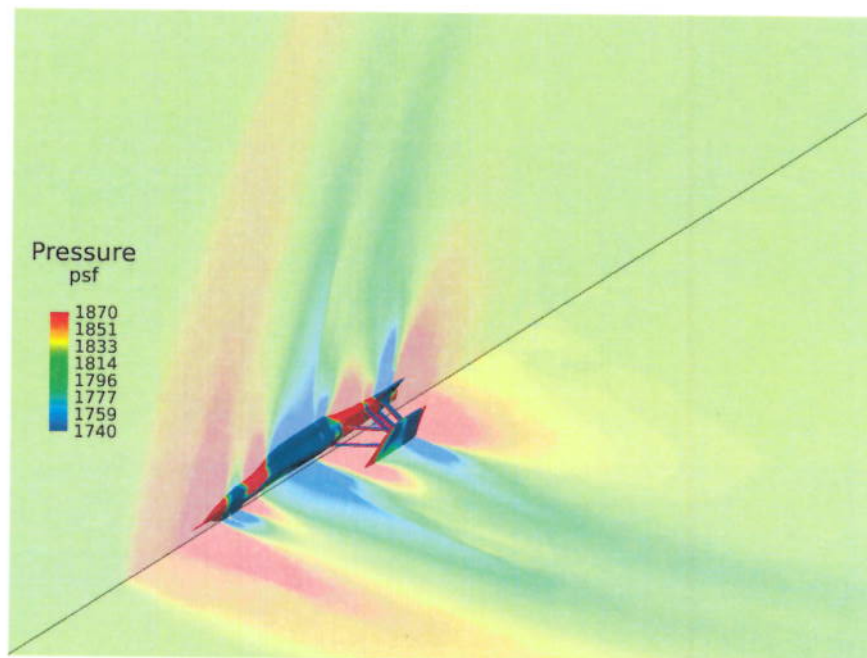
Pressure Distribution Mach 0.9
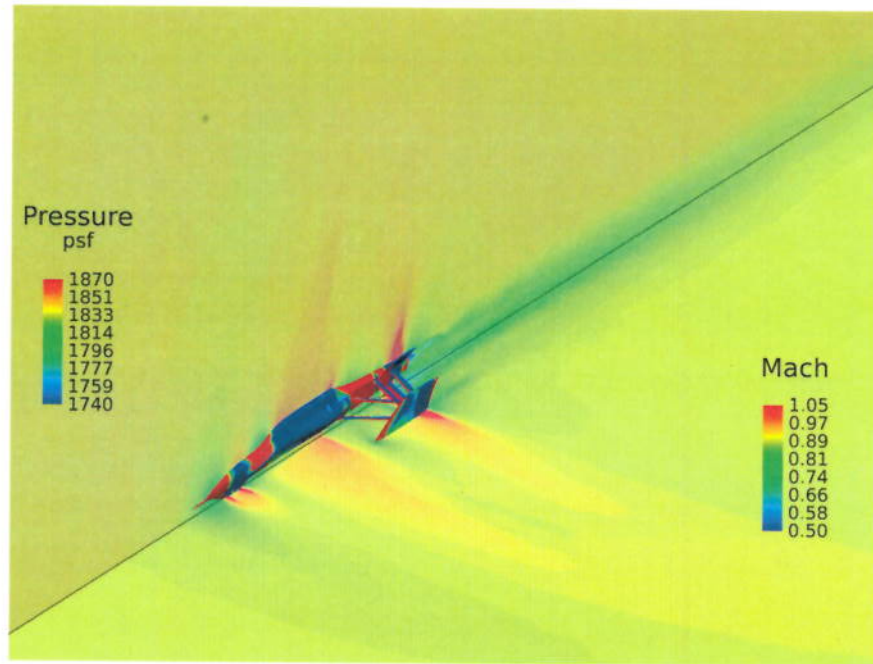
Mach/Pressure Distribution Mach 0.9
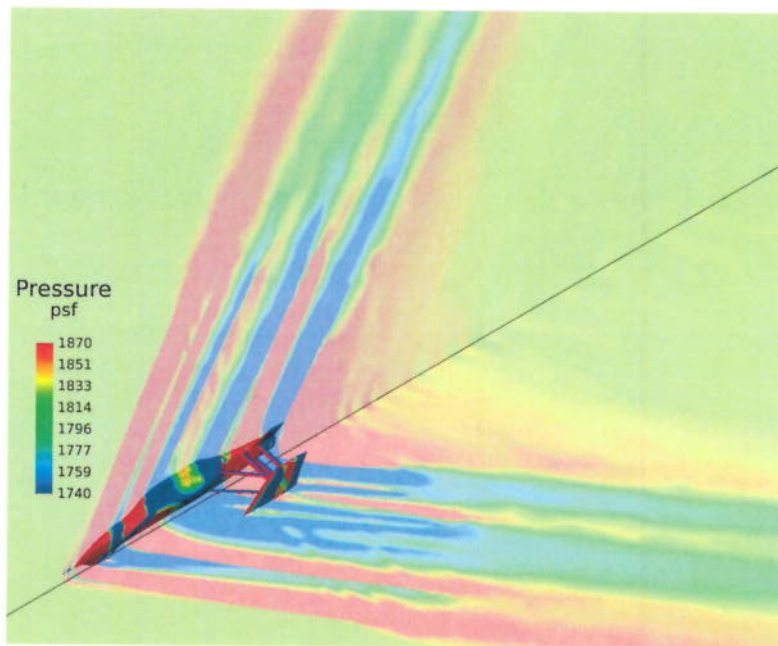
Pressure Distribution Mach 1.2
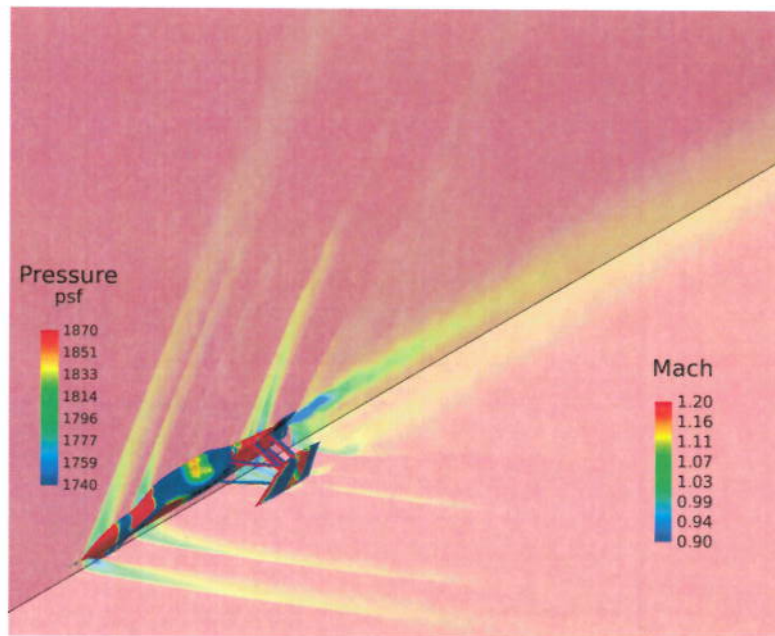
Mach/Pressure Distribution Mach 1.2
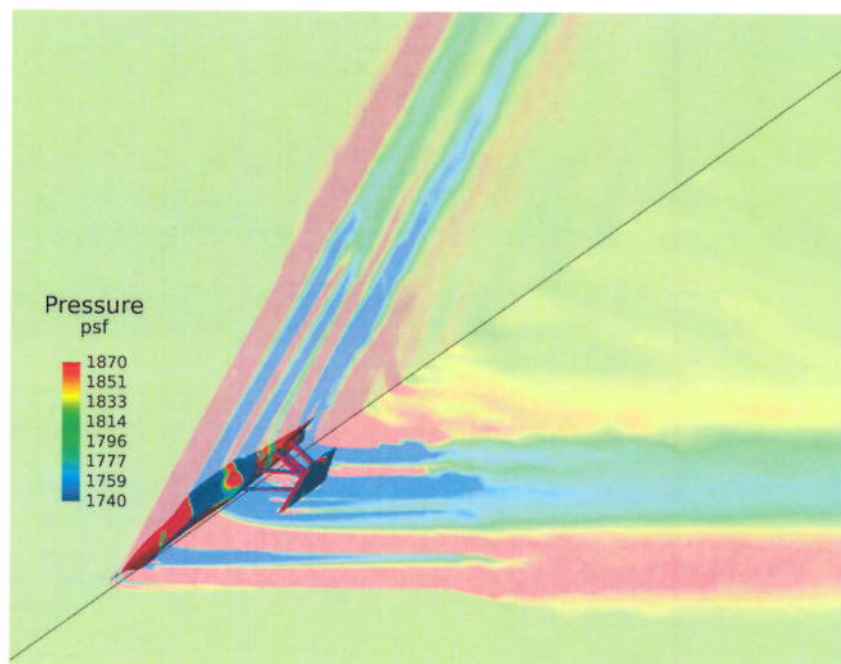
Pressure Distribution Mach 1.5

Propulsive Wing
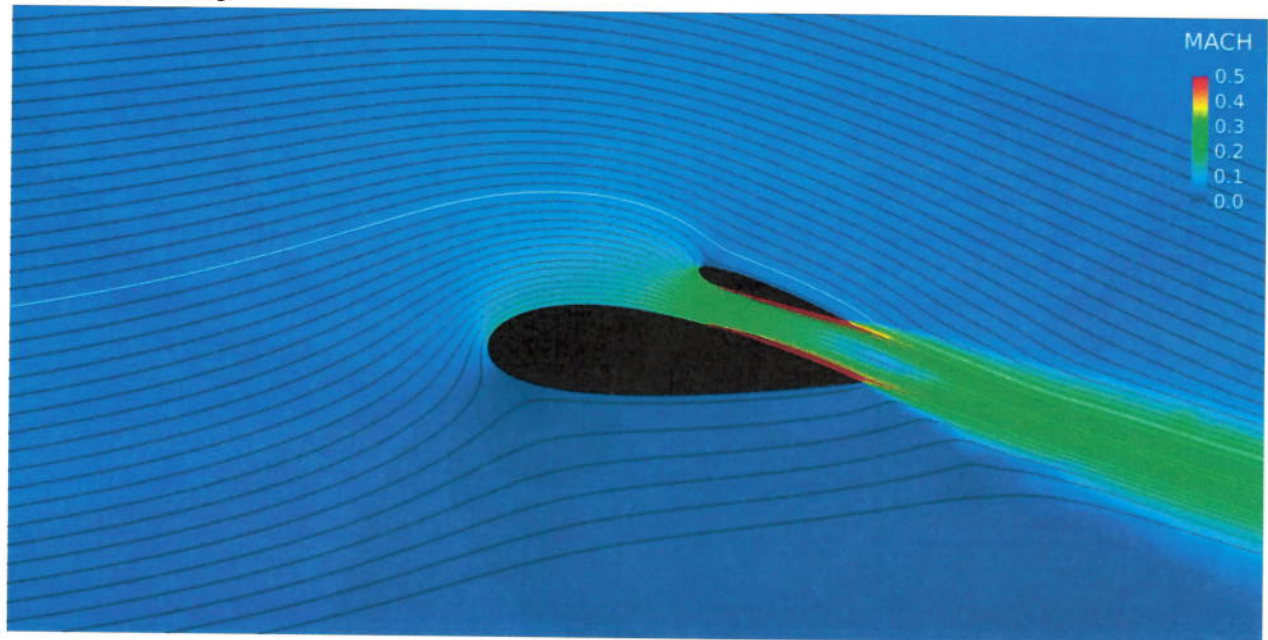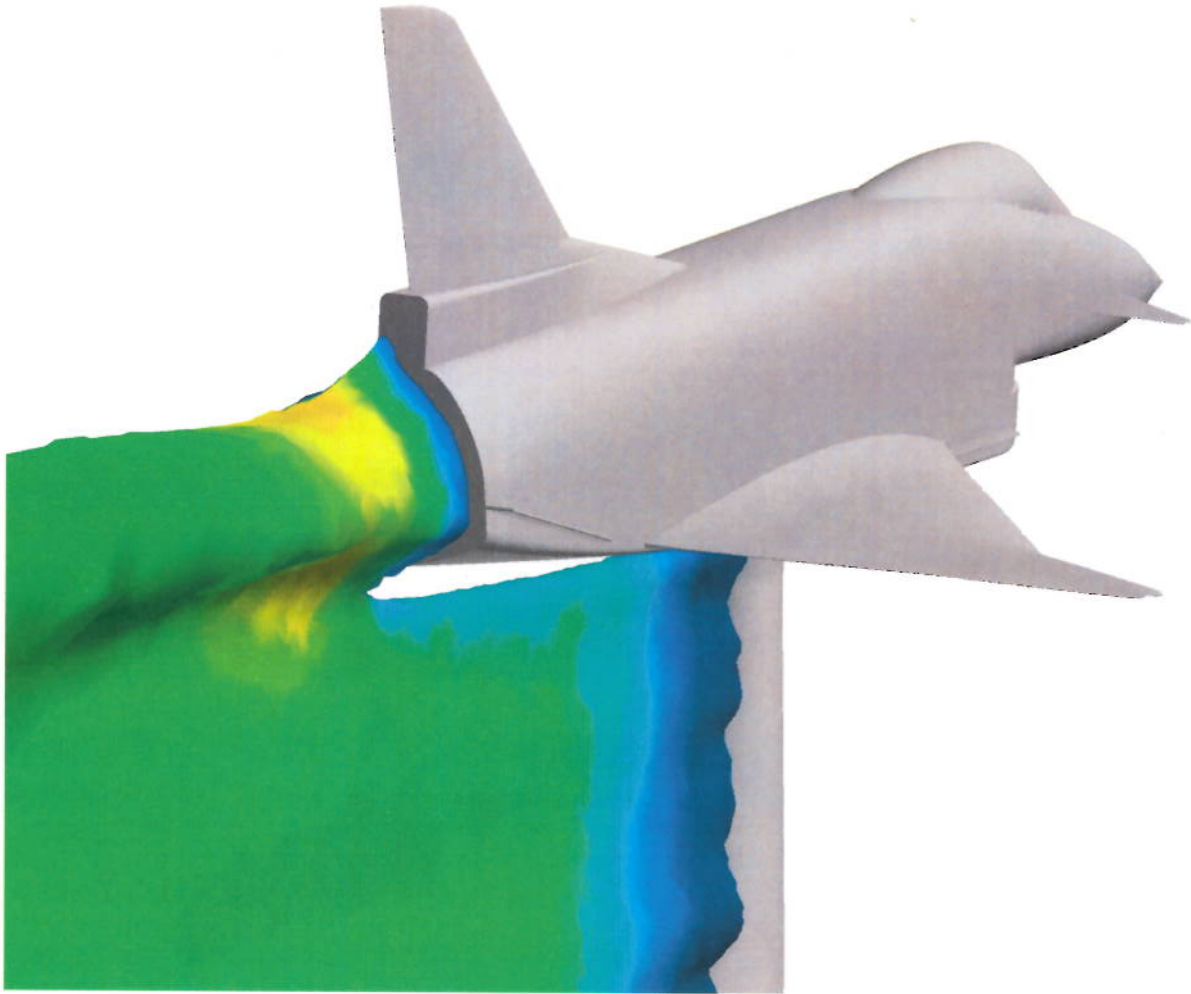

Flow visualization at 5 degrees AoA
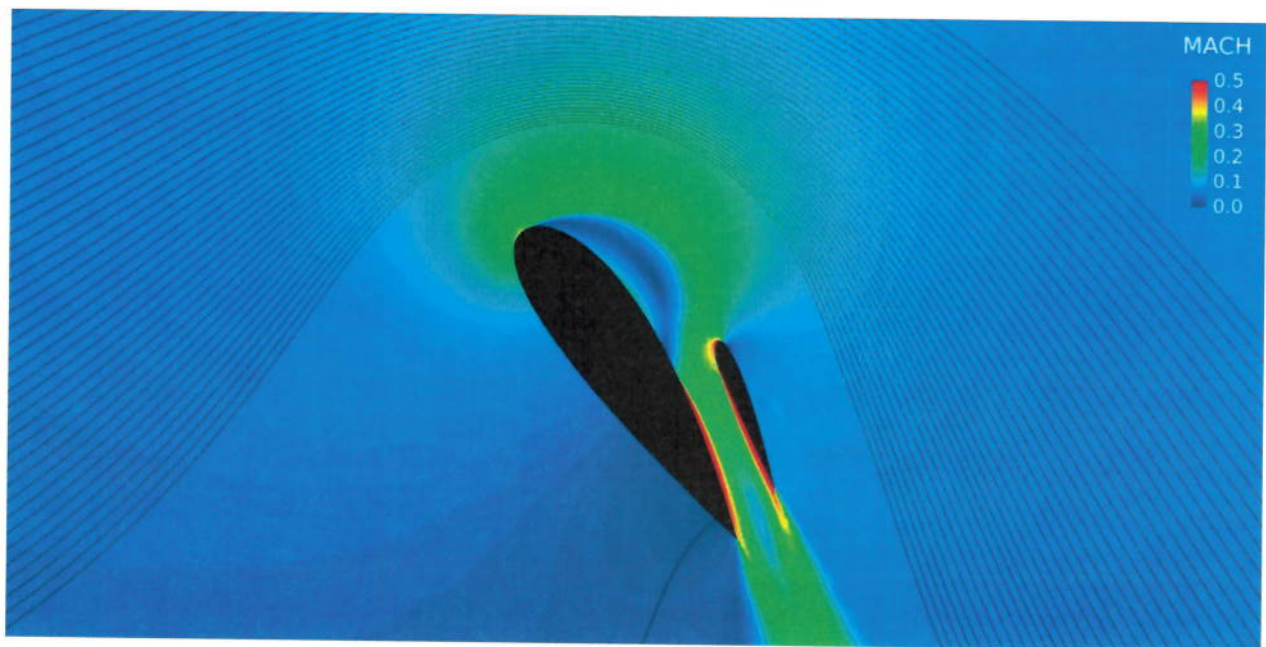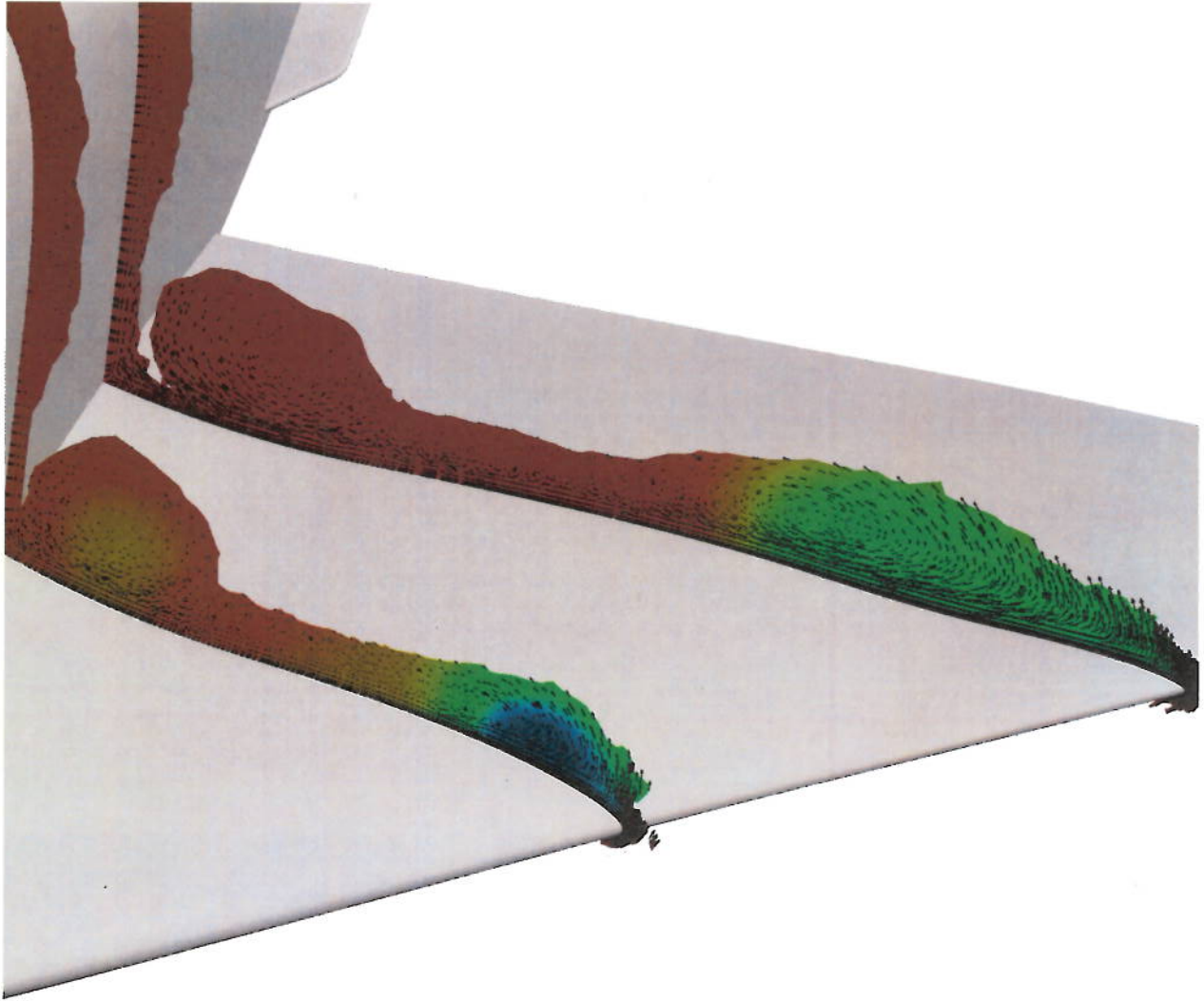

Flow visualization at 55 degrees AoA
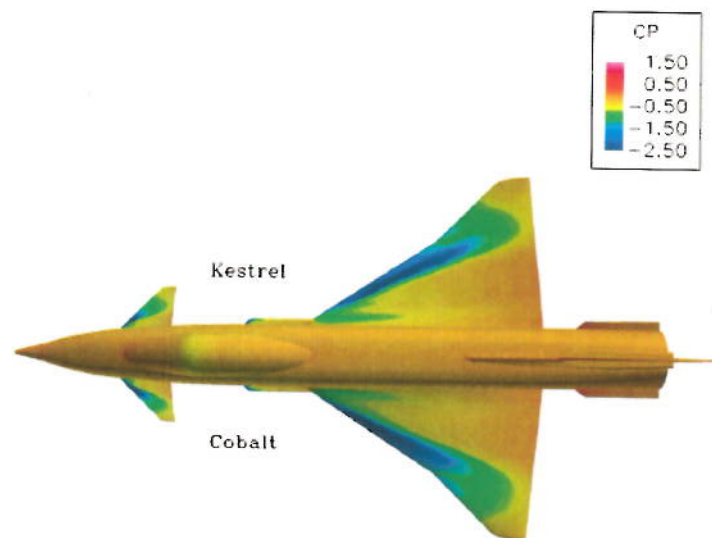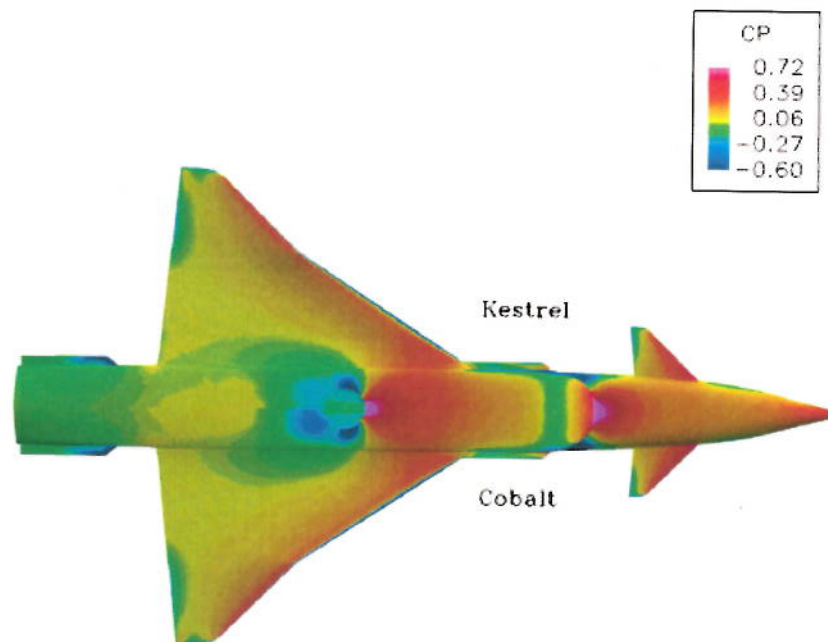
(d) $\alpha = 14.97^o$
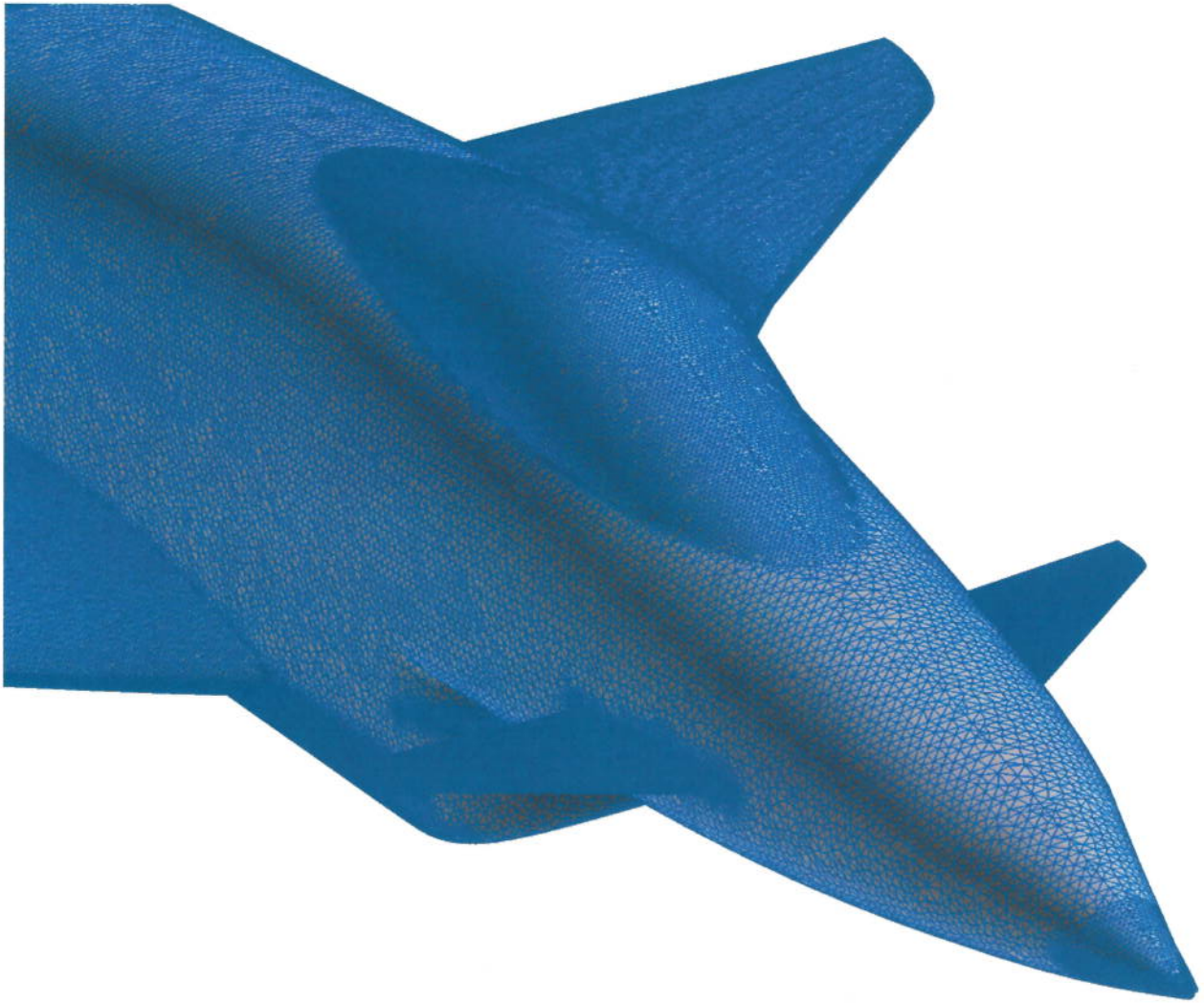
C_p visualization at an angle of attack of 14.97 degrees

Visualization of wake behind belly-mounted sting of X-31 model
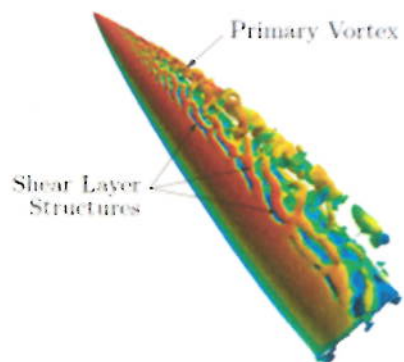
Cobalt surface pressures at two tap locations
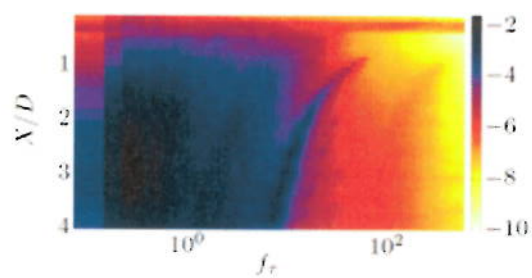
X-31 aircraft mesh

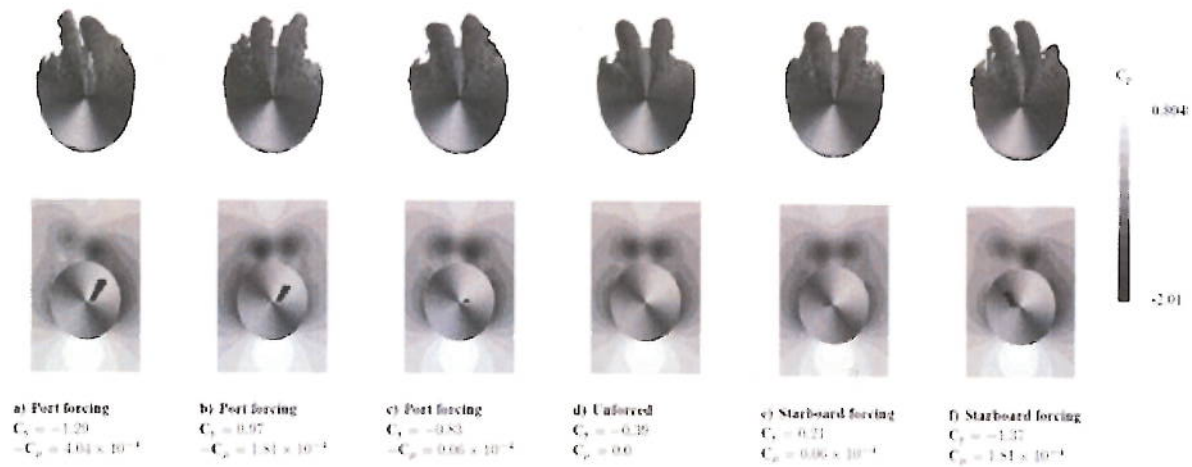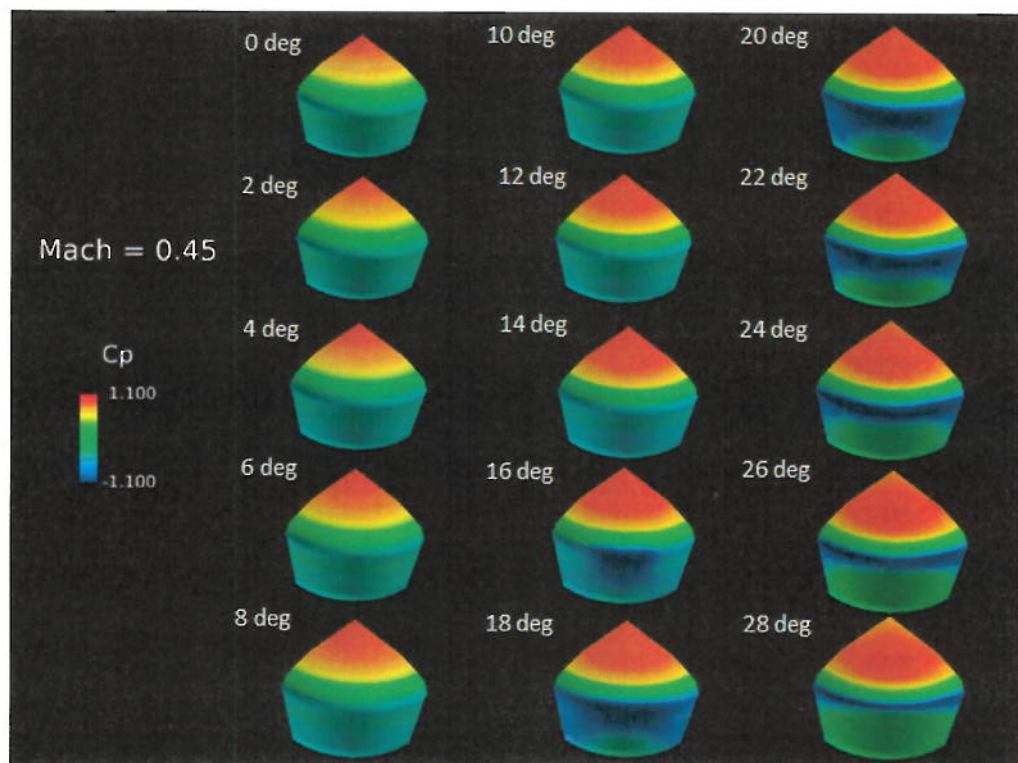X-31 predicted vertical flows of Cobalt and Kestrel solvers

Tangent Ogive Nose

(a) Q-isosurface colored by pressure

(b) Normalized frequency content

a) Port forcing
$C_y = -1.20$
$-C_p = 4.04 \times 10^{-4}$

b) Port forcing
$C_y = 0.97$
$-C_p = 1.81 \times 10^{-4}$

c) Port forcing
$C_y = -0.83$
$-C_p = 0.06 \times 10^{-4}$

d) Unforced
$C_y = -0.39$
$C_p = 0.0$

e) Starboard forcing
$C_y = 0.21$
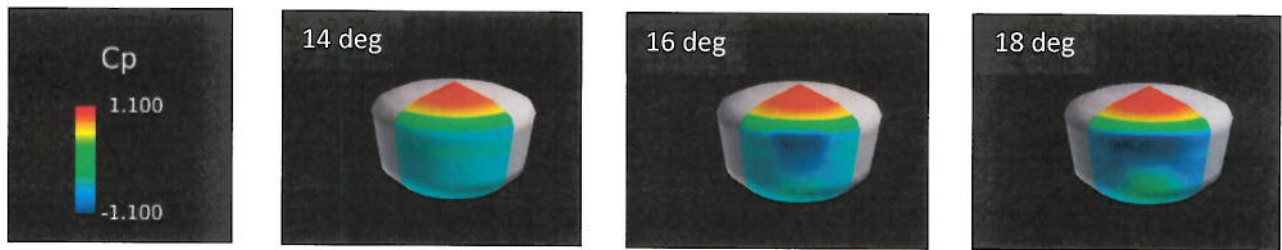$C_p = 0.06 \times 10^{-4}$

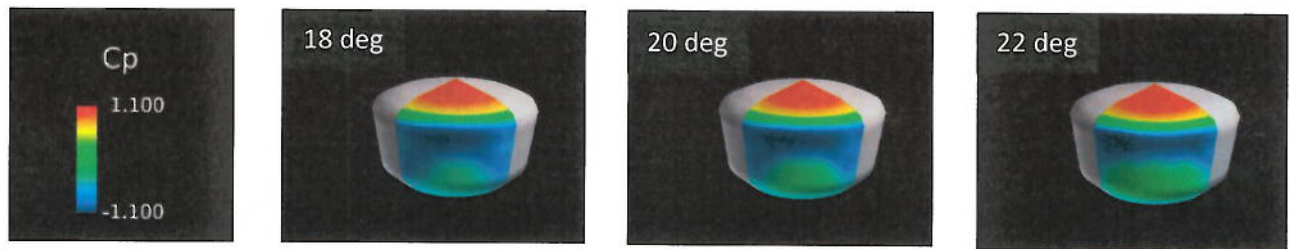f) Starboard forcing
$C_y = -1.37$
$C_p = 1.81 \times 10^{-4}$

NASA Maraia Capsule

Wind Tunnel Pressure Data Interpolation, M = 0.45

Maraia Capsule Pressure Contours 14, 16, 18 degrees (M= 0.45)

Maraia Capsule Pressure Contours 18, 20, 22 degrees (M= 0.45)